

EX/4-6Ra



Studies of HRS H-mode plasma in the JFT-2M tokamak



JFT-2M

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EX/4-6Rb

Electrostatic fluctuation and fluctuation- induced particle flux during formation of the edge transport barrier in the JFT-2M tokamak

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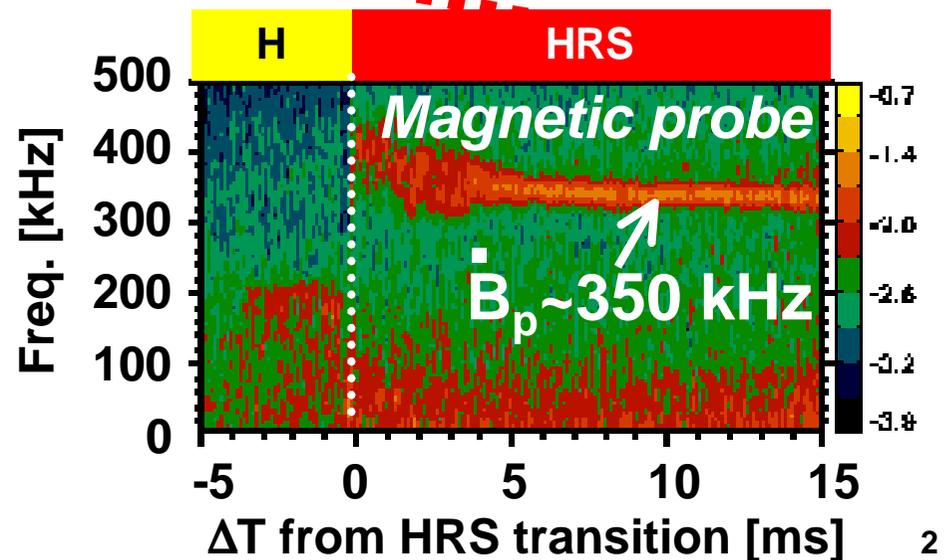
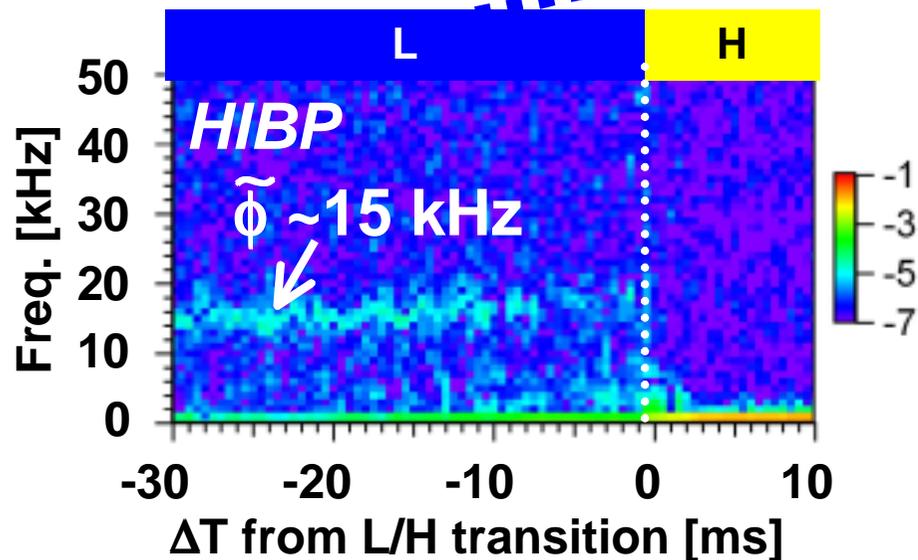
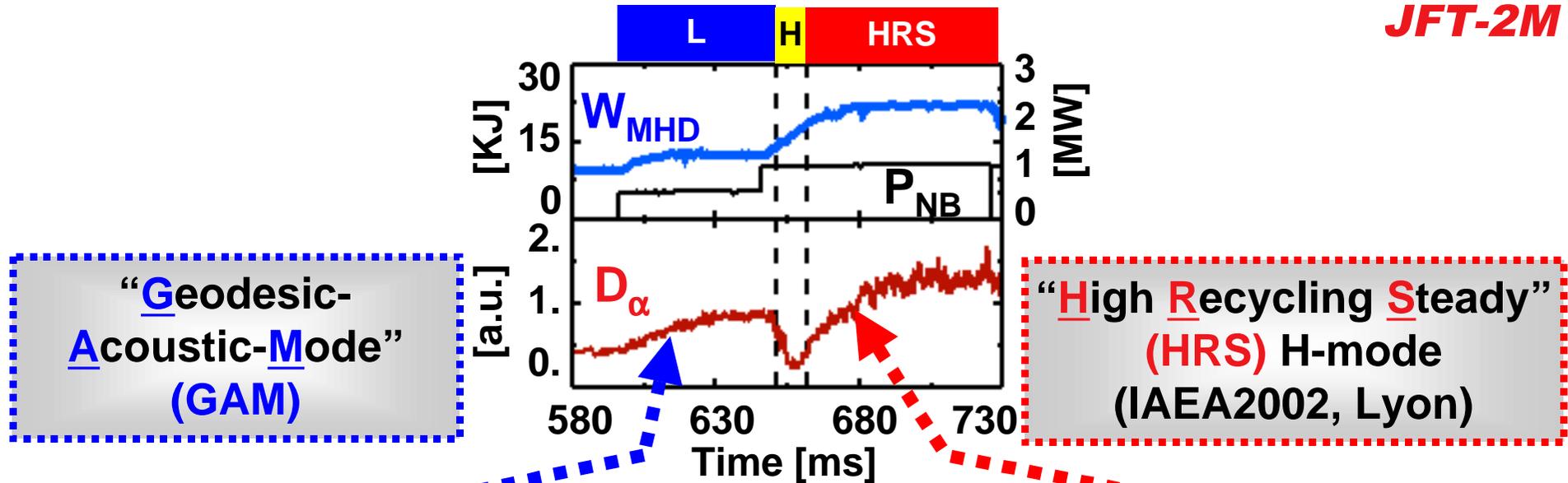
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Introduction

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Outline

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“Geodesic-Acoustic-Mode” (GAM) in L-mode

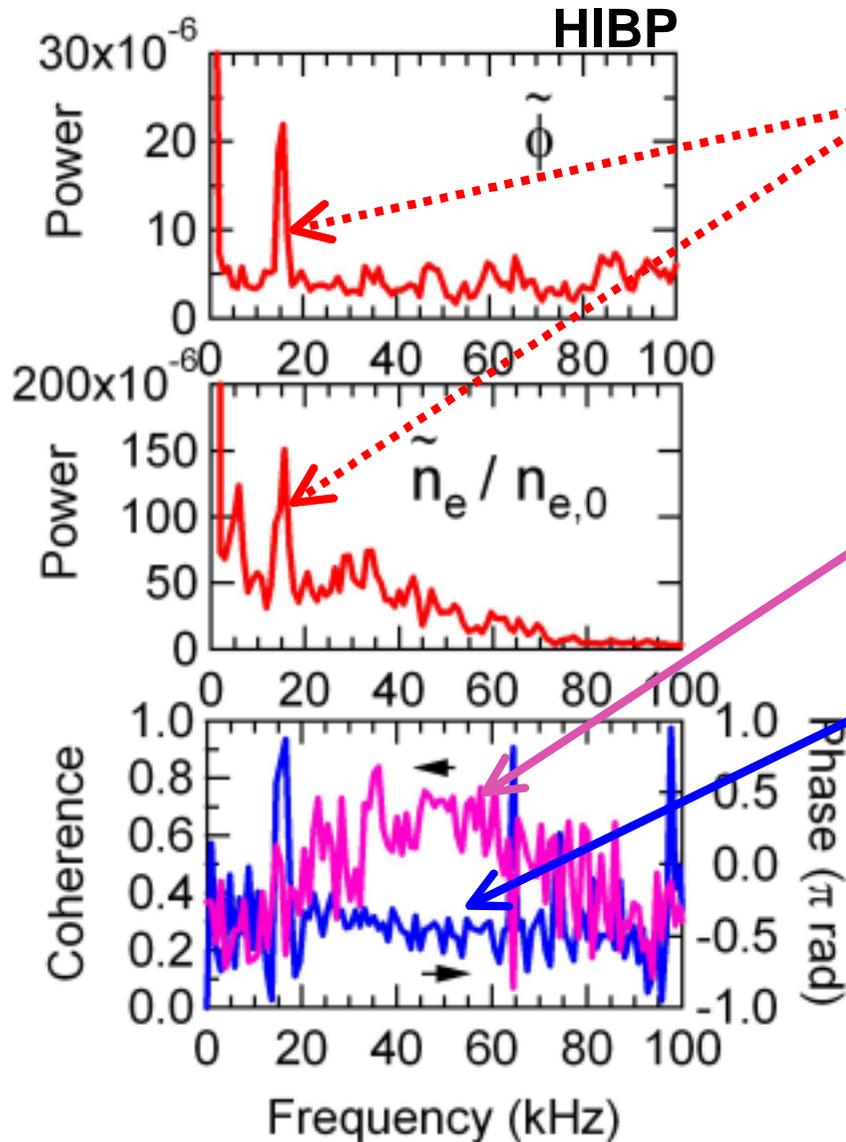
- Characteristics
- Relation with ambient turbulence
- Contribution to particle flux

“High Recycling Steady” (HRS) H-mode regime

- Global behaviors
- Pedestal characteristics and Role of edge MHD activities
- Access conditions in terms of dimensionless parameters

Potential and density fluctuations from HIBP measurements in L-mode plasma

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• A significant peak in both *potential and density power spectra* at $f_{GAM} \sim 15\text{kHz}$

$$f_{GAM} = \frac{1}{2\pi R} \sqrt{\frac{T_i + T_e}{M_i}} = 19 \text{ (kHz)}$$

• Higher coherence between 30–60 kHz

• Phase difference is about $\pi/2$

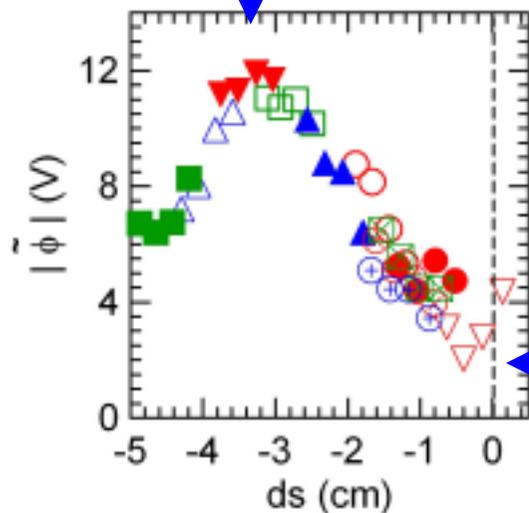


Ambient fluctuation with 30–60kHz mainly contributes to particle flux

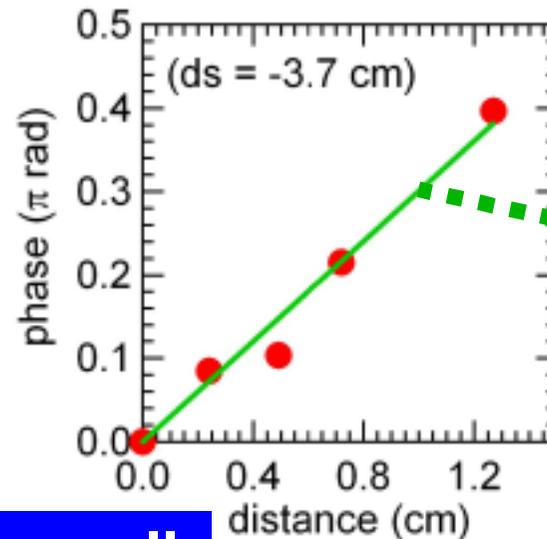
Other observations also suggest that oscillations are quite similar to **GAM**

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$|\phi(f_{\text{GAM}})|$ has maximum at ~ 3 cm inside R_{sep} ($\rho \sim 0.85$)



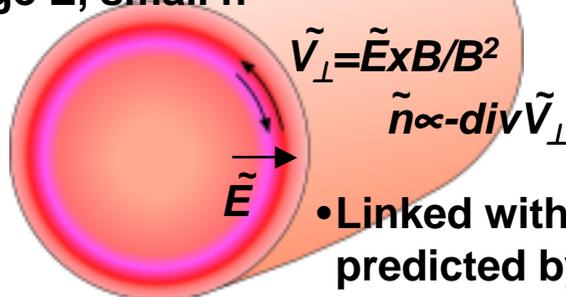
$|\phi(f_{\text{GAM}})|$ small near R_{sep}



$k_r \sim 1 \text{ cm}^{-1}$
at f_{GAM}

\Downarrow
 $k_r \rho_i \sim 0.26 < 1$

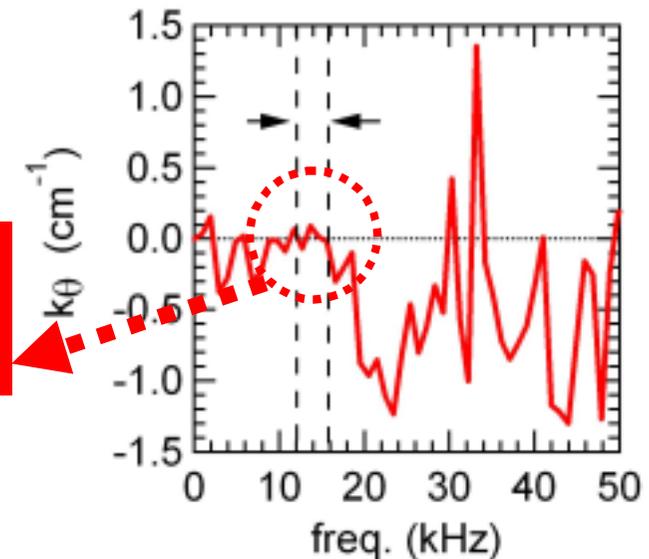
- Electrostatic (low m) acoustic mode (i.e. $\tilde{B} \sim 0$)
- Large \tilde{E} , small \tilde{n}



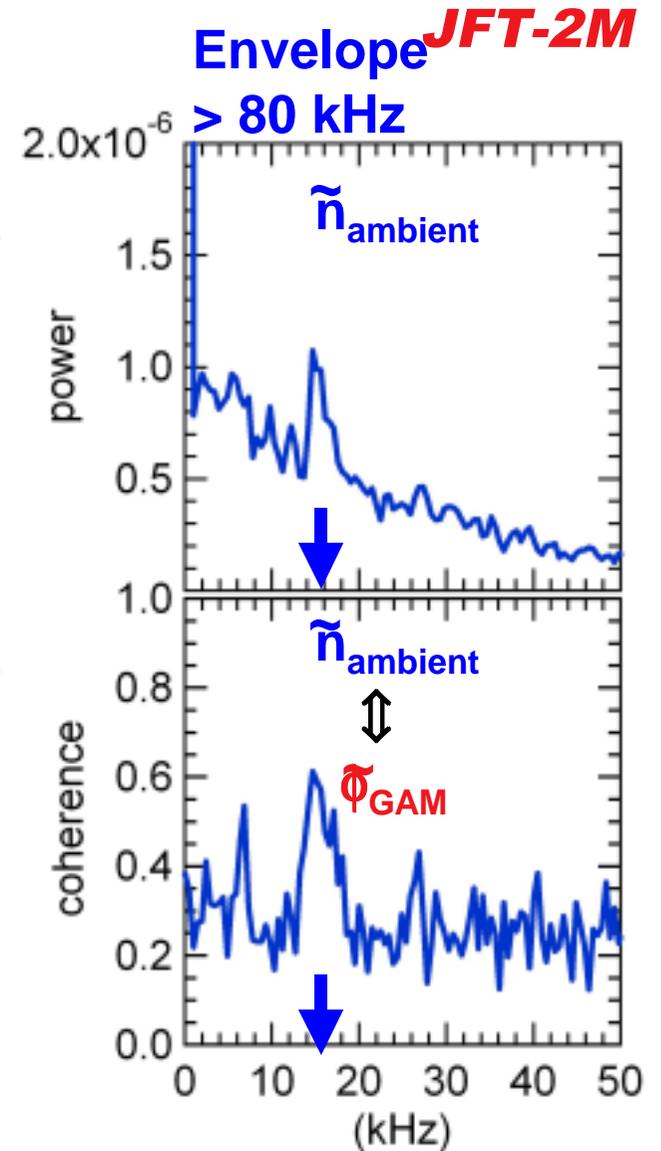
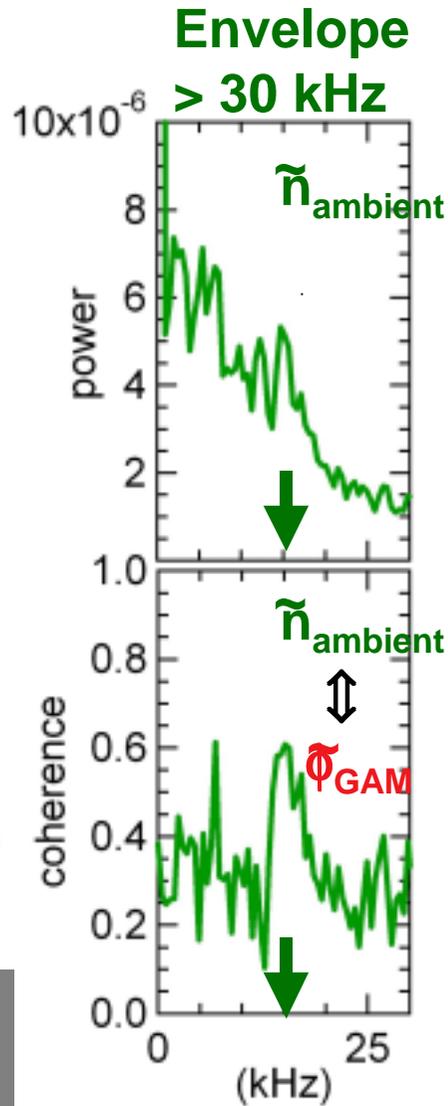
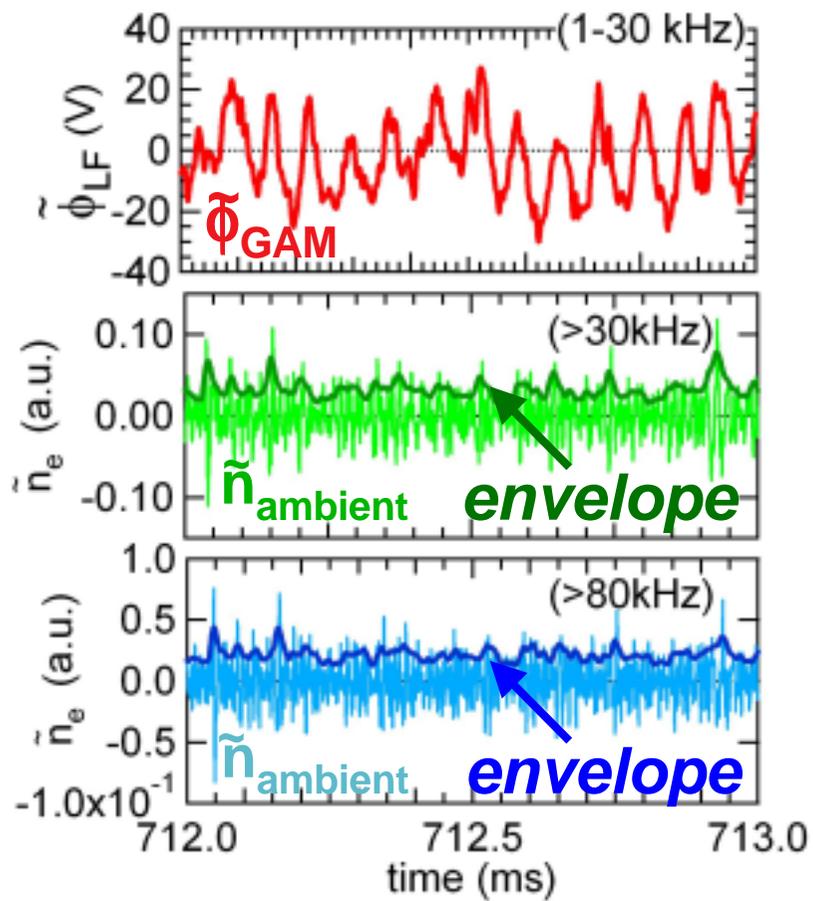
• Linked with zonal flows, predicted by codes

$k_\theta \sim 0 \text{ cm}^{-1}$
at f_{GAM}

\Downarrow
 $m \sim 0$

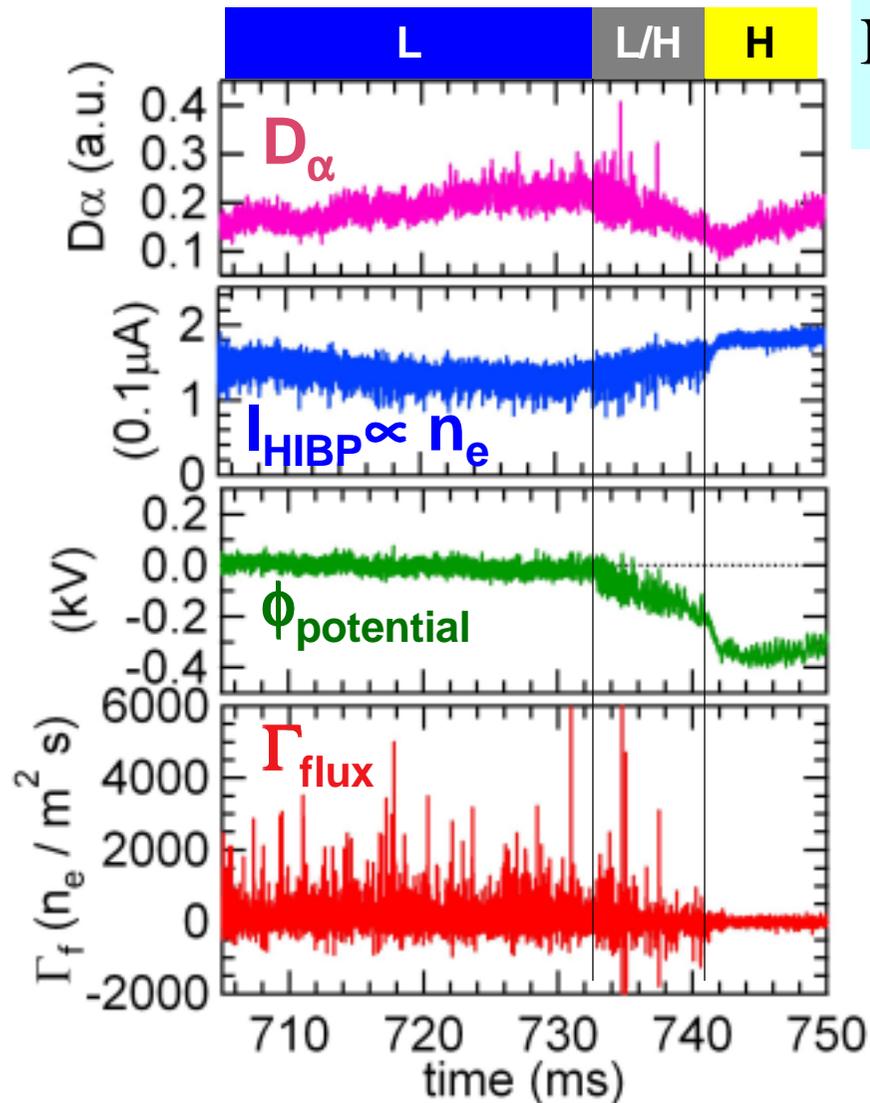


Significant coherence between $\tilde{\Phi}_{\text{GAM}}$ and envelope of $\tilde{n}_{\text{ambient}}$

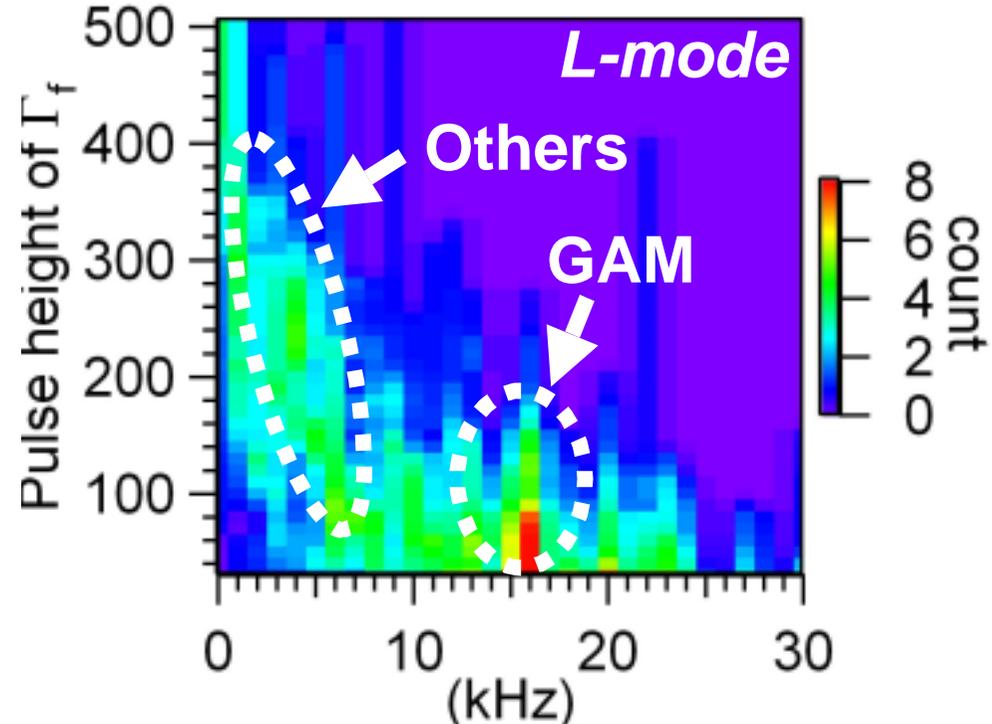


The modulation of $\tilde{n}_{\text{ambient}}$ correlates with GAM

Particle flux exhibits an intermittent behavior associated with GAM



$$\Gamma_f = \left\langle \tilde{n}_e \frac{\tilde{E}_\theta}{B_t} \right\rangle = n_{e,0} \left\langle \frac{\tilde{I}_{\text{HIBP}}}{I_{\text{HIBP},0}} \frac{\tilde{E}_\theta}{B_t} \right\rangle \quad \text{JFT-2M}$$



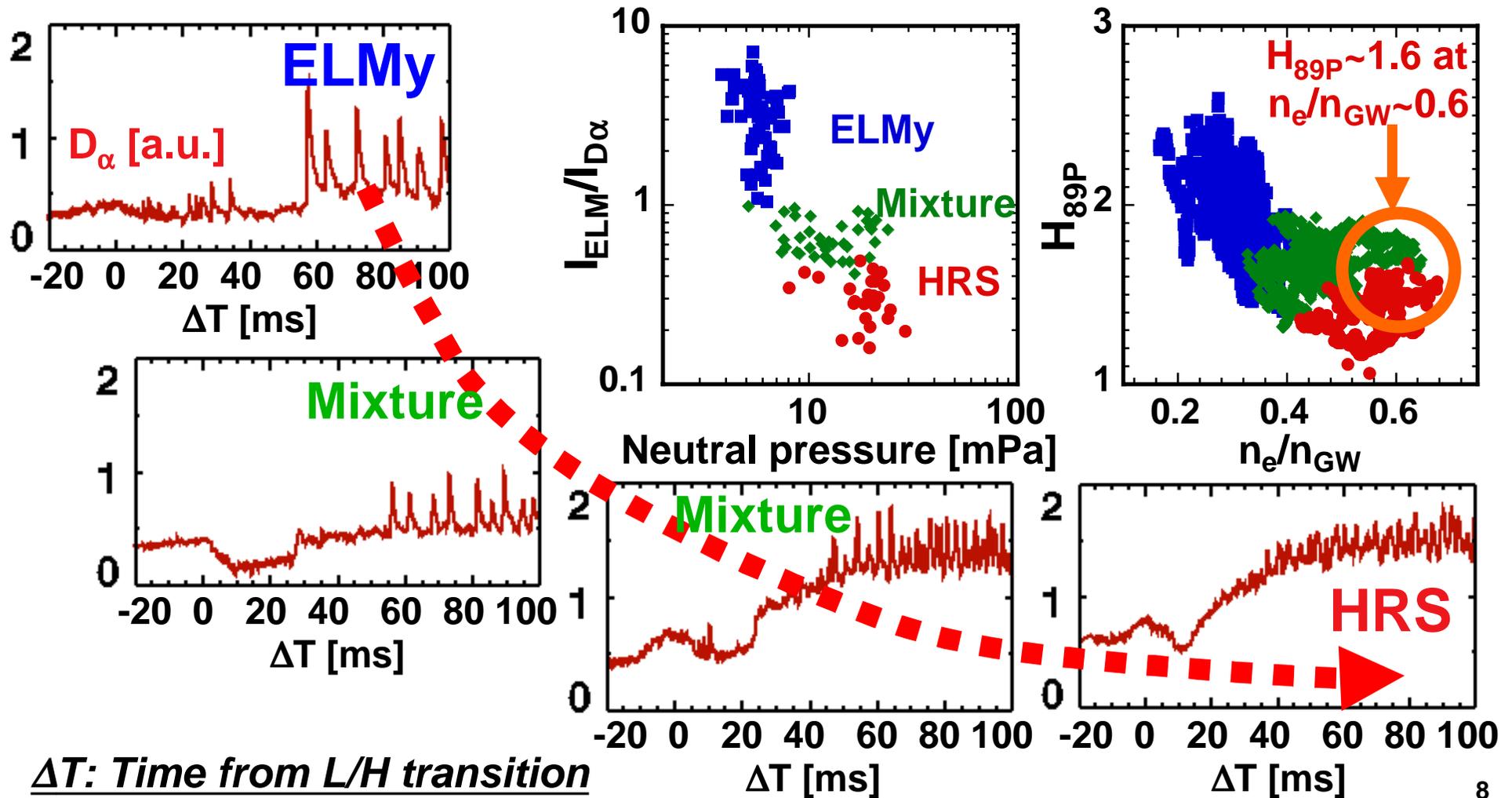
\Rightarrow Other mechanism may also contribute to intermittency on the particle flux

Disappearance of large ELMs in “**H**igh **R**ecycling **S**teady” (**HRS**) H-mode regime

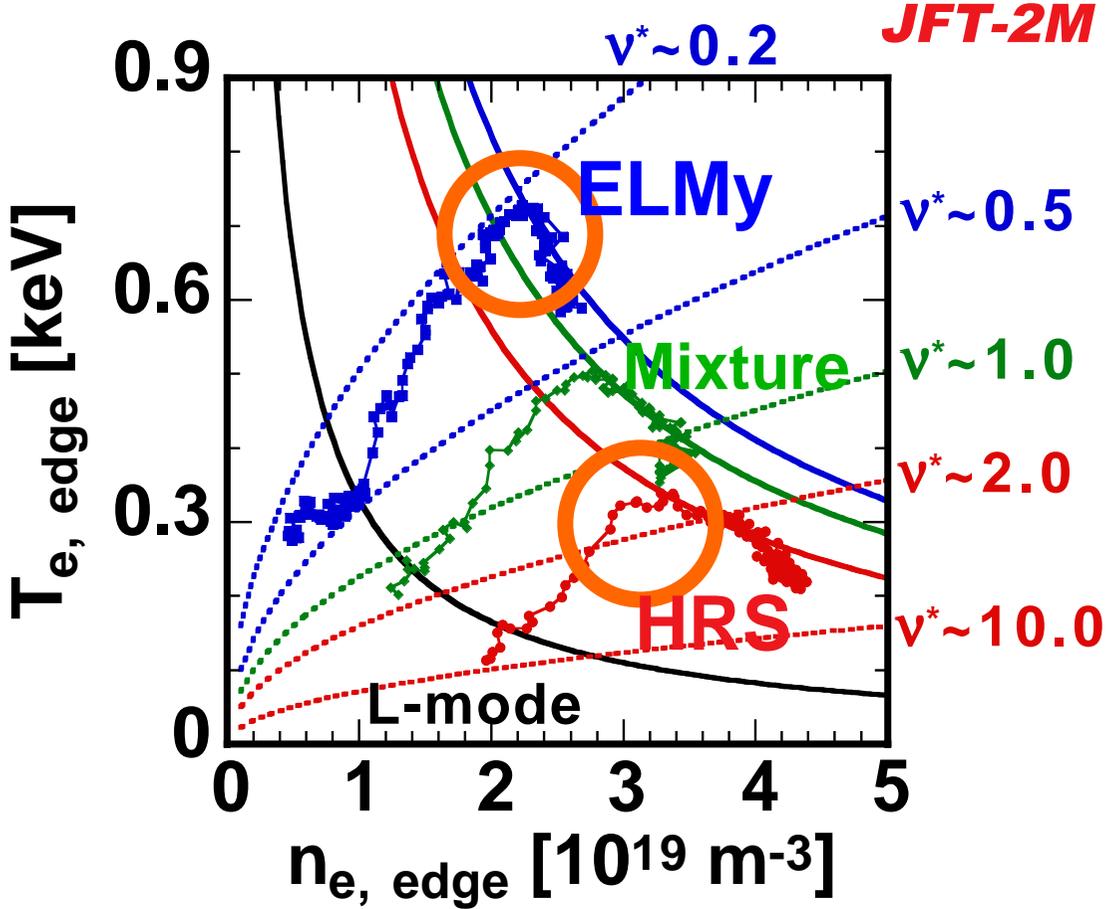
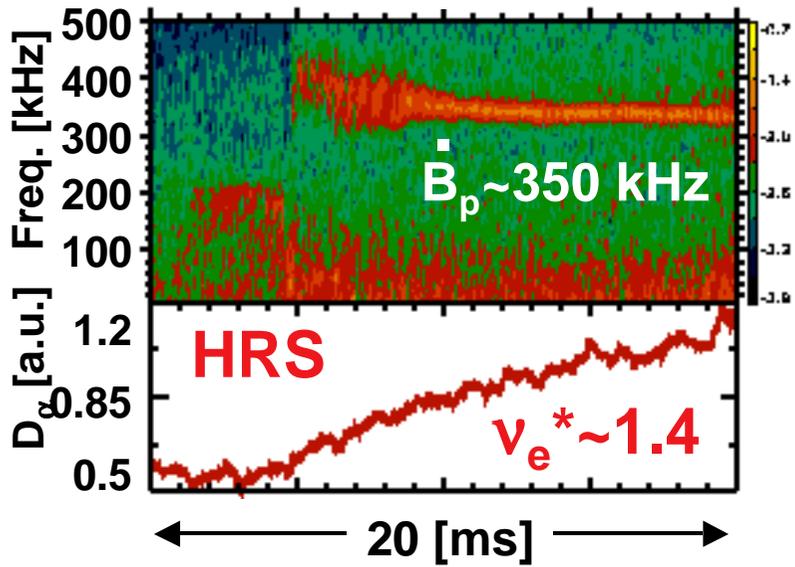
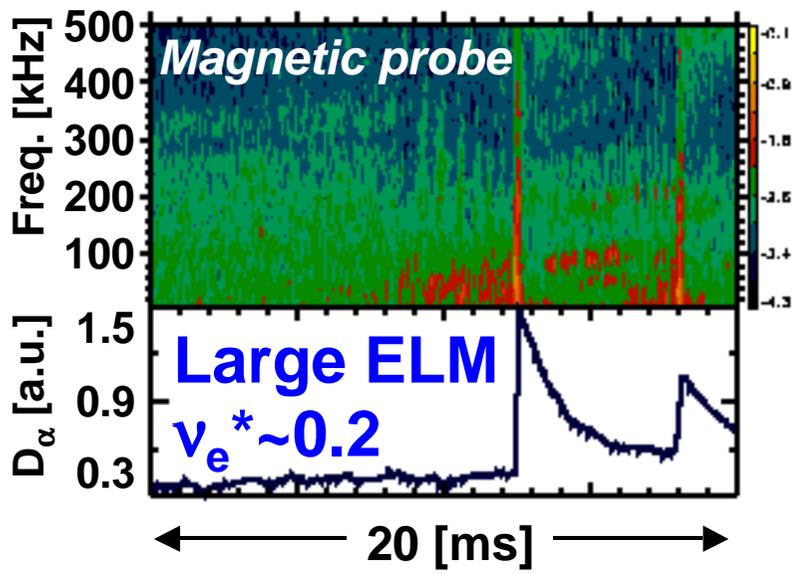
New operating regime obtained after boronization

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⇒ Essential to minimize erosion of the divertor tiles

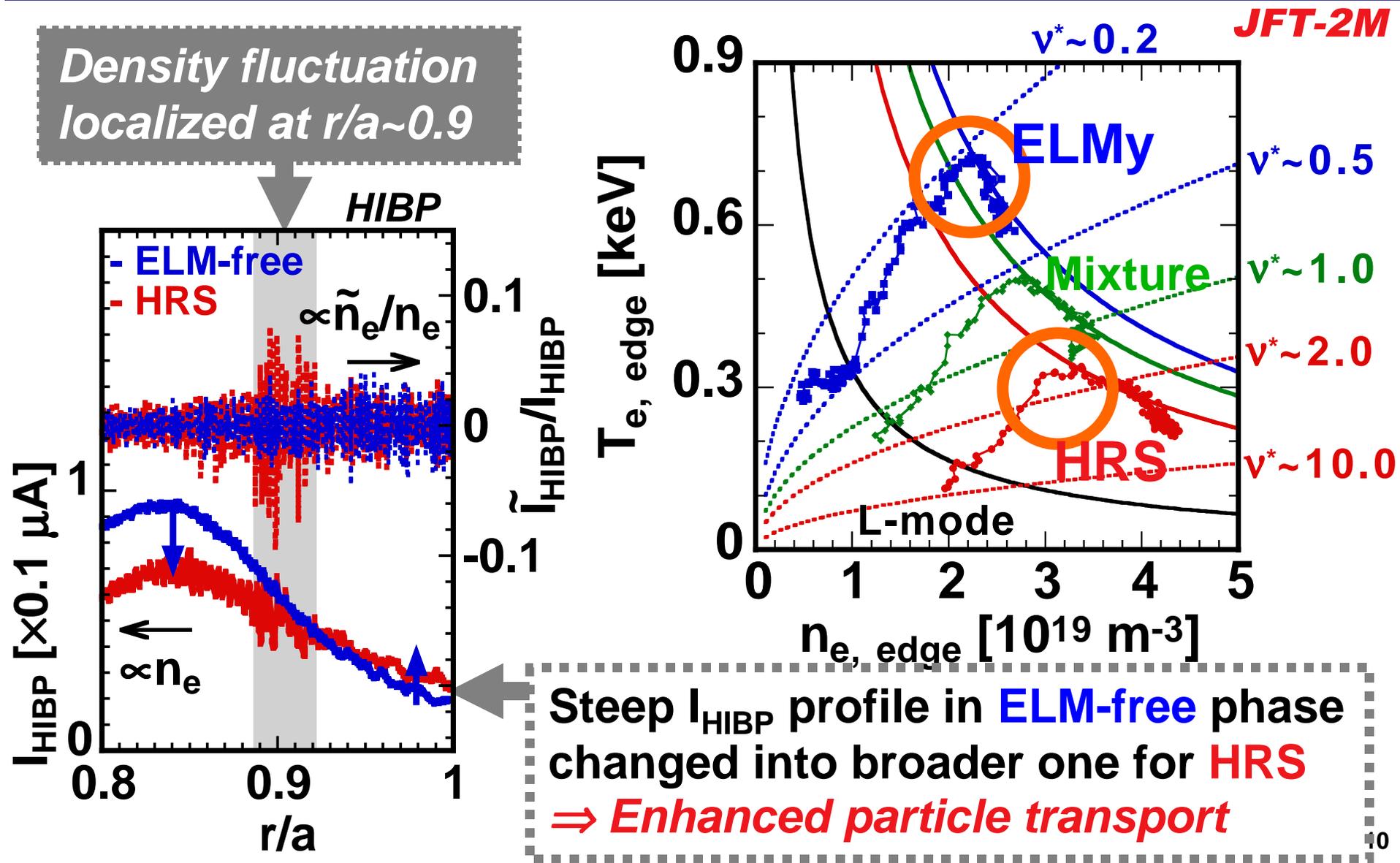


Pedestal pressure for **HRS** was limited at $\sim 70\%$ of **ELMy** discharge



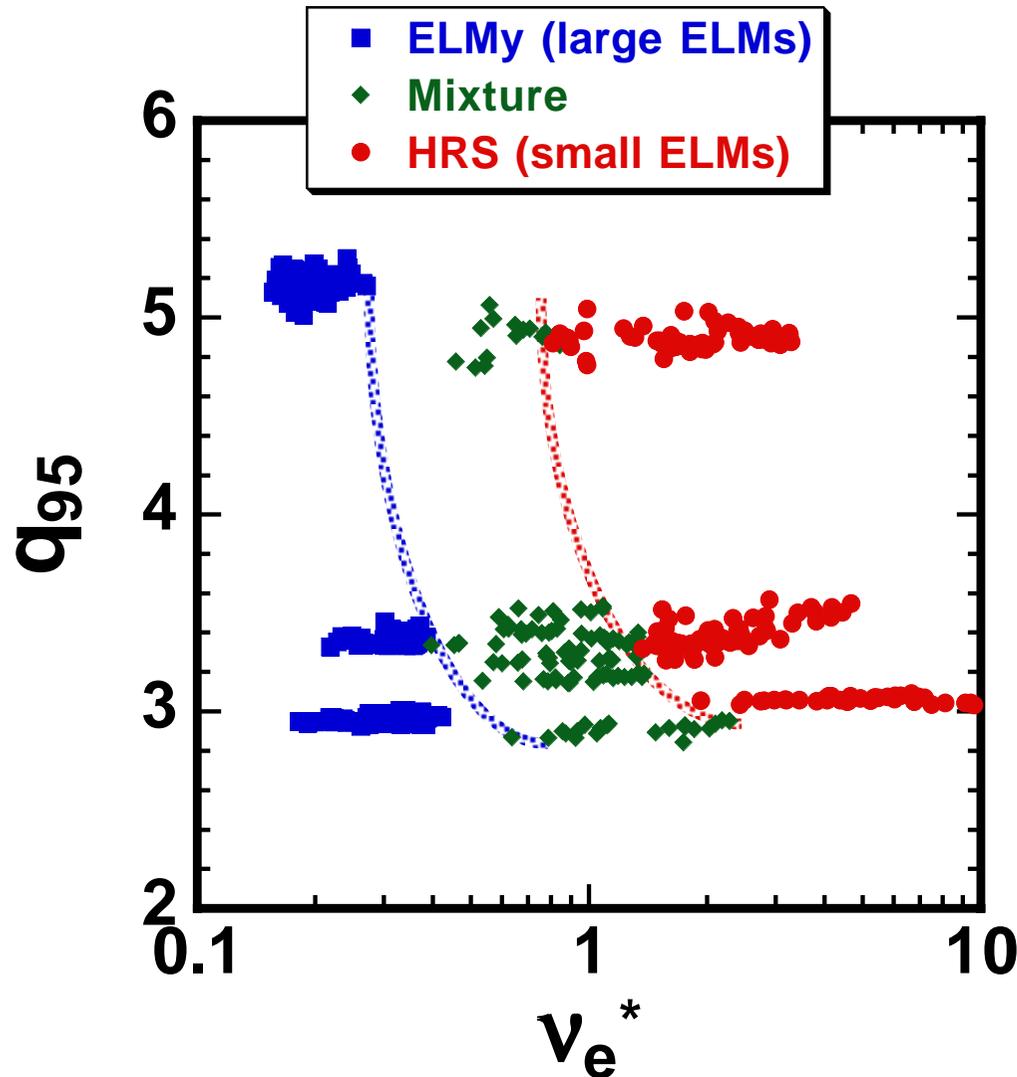
\Rightarrow Edge MHD activities may keep $p_{e, edge}$ below the level needed to induce a large ELM

Pedestal pressure for **HRS** was limited at $\sim 70\%$ of **ELMy** discharge



Access conditions in $q_{95}-v_e^*$ space

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■ ELMs (large ELMs)

$$v_e^* < 1$$

◆ Mixture

$$v_e^* \sim 1$$

● HRS (small ELMs)

$$v_e^* \geq 1$$

Operational limit reduced
for higher q_{95}

$$v_e^* = 6.9 \times 10^{-18} \frac{q_{95} R n_e \ln \Lambda}{T_e^2 \epsilon^{3/2}}$$

Summary

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Electrostatic fluctuations (GAM) in L-mode

- The modulation of $\tilde{n}_{\text{ambient}}$ correlates with GAM
- Fluctuation induced particle flux exhibits an intermittent behavior associated with GAM, though other mechanism may also contribute to intermittency on the particle flux

HRS H-mode

- Pedestal pressure for HRS is limited at its own critical value below the level needed to induce a large ELM
- HRS is associated with edge MHD activities
- A high collisionality phenomena